Optimization of Ni-YSZ Solid Oxide Fuel Cell anodes by surface laser melting

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Introduction

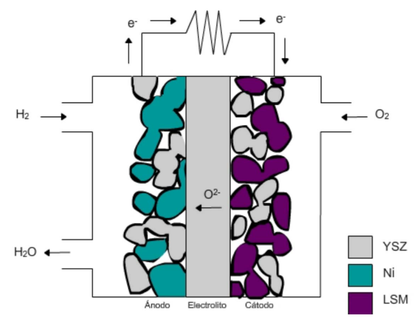
A **cermet** composed of a metallic component (**nickel**) and a ceramic matrix (**yttria stabilized zirconia**) is commonly used as anode for Solid Oxide Fuel Cells (**SOFC**). The disadvantages of this material are the poor redox stability, low tolerance for sulphur and carbon deposition and the tendency of nickel agglomeration after prolonged operation. In the present work we pretend to improve the microstructural stability and the electrical properties of the NiO-YSZ cermet by surface laser melting.

Symmetrical cells, consisting of two **NiO-YSZ anodes** (~50 μm thickness) separated by a relatively thin YSZ electrolyte (~300 μm) were fabricated by convectional ceramic techniques. Subsequently, laser melting treatments of the two anodes were performed using a **CO_2 laser** system, producing a NiO-YSZ **eutectic lamellar** microstructure. Symmetrical processed samples (**eutectic**) were electrically characterized by impedance spectroscopy, and the results were compared with non-processed samples (**ceramic**). Comparing the results of both samples, the polarization resistance at higher temperatures (~900 ºC) is about 0.5 Ωcm^2 for both the eutectic and the ceramic sample. However, at lower temperatures (~800 ºC) the polarization resistance for both samples differs considerably (3.0 and 1.5 Ωcm^2 for the ceramic and eutectic sample, respectively). These experiments confirmed that **optimization of the microstructure** by laser surface treatment plays a crucial role in the electrochemical properties of the anode cermets.

Experimental

Results

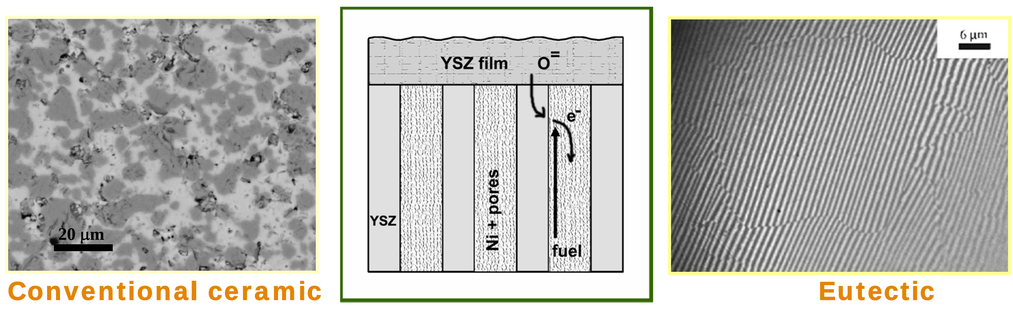
1. SOFC diagram



O^{2-} (electrolyte) + H_2 (fuel) → H_2O + 2e$^-$ (anode)

Anode reaction

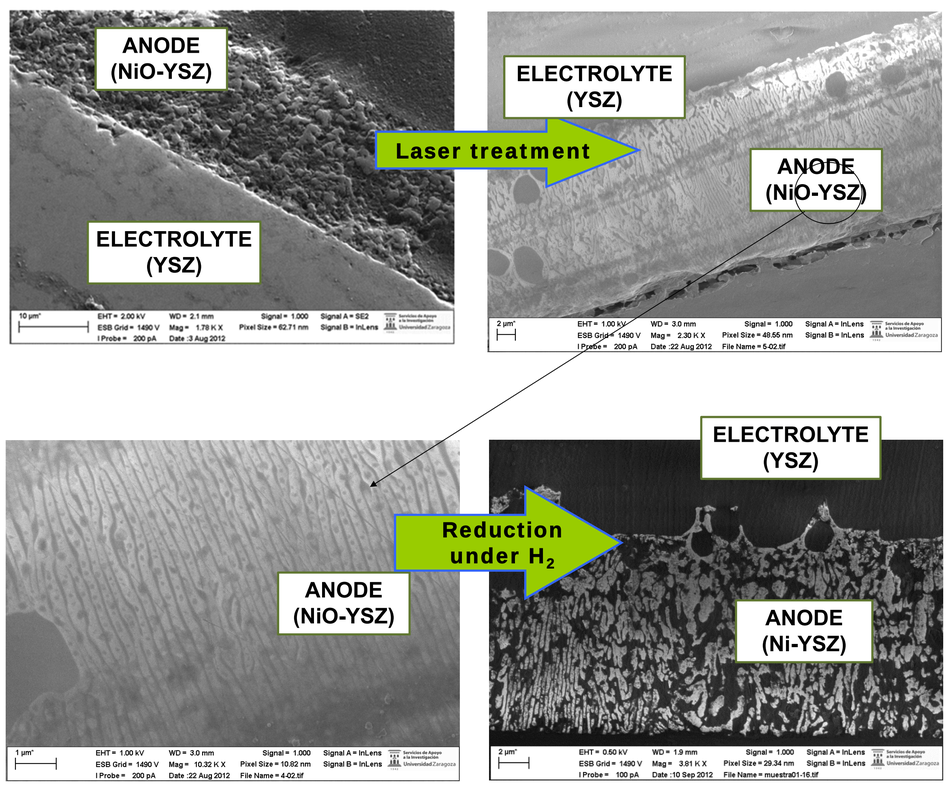
2. Eutectic growth



Conventional ceramic — Eutectic

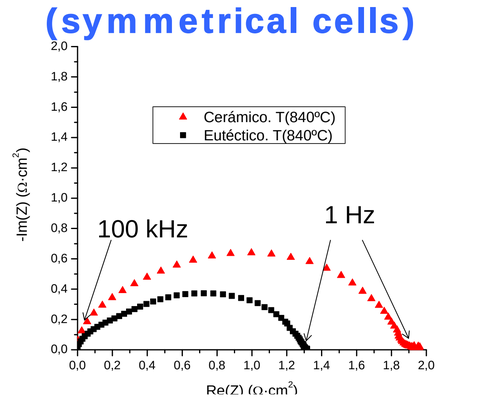
-Lamelar microestructure (~400 nm width)
-Easy gas flow and current collection
-Better microstructural stability and adhesion between phases (minimization of the interfatial energy)

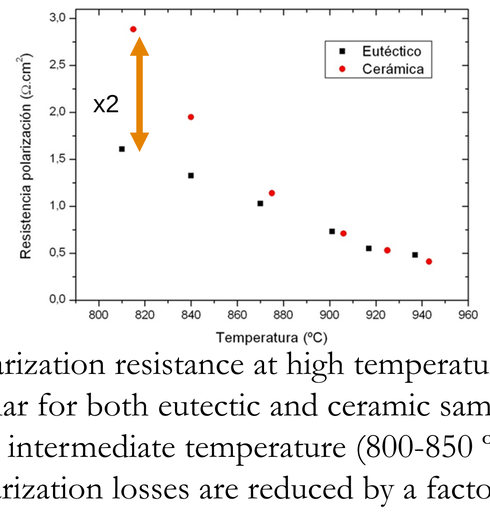
3. Anode / electrolyte microstructure



NiO-YSZ eutectic with homogeneous lamellar microstructure

4. Electochemical characterization (symmetrical cells)





Polarization resistance at high temperature is similar for both eutectic and ceramic samples. At intermediate temperature (800-850 ºC) polarization losses are reduced by a factor of 2 due to the alignment of the microestructure

Conclusions

We have fabricated YSZ pellets (~300 μm thickness), and then coated with NiO-YSZ by dip coating (~20 μm thickness)

Samples were surface treated using a CO_2 laser at 100 W of power and a solidification rate of 10 mm/s), obtaining a NiO-YSZ eutectic lamellar microstructure, as observed by SEM.

Electrochemical impedance spectroscopy was performed (EIS) of symmetrical cells showing that the polarization resistance at ~900 ºC is about 0.5 **Ω**cm^2 for both the eutectic and ceramic sample. However, at ~800 ºC, the polarization resistance of the eutectic sample is significantly reduced (1.5 **Ω**cm^2) in comparison with the ceramic sample (3.0 **Ω**cm^2).

Microstructure plays a crucial role in the electrochemical properties of SOFC anodes.

References

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